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Review Article

Nanotechnology against COVID-19

Mohsen Mhadbhi[1]* and Khalil Khamassi[2]

[1]Laboratory of Useful Materials, National Institute of Research and Physical-chemical Analysis, Technopole Sidi Thabet, Tunisia

[2]Field Crop Laboratory, National Agricultural Research Institute of Tunisia, University of Carthage, Street Hedi Karray, Menzah 1, Tunis, Tunisia

***Corresponding Author:** Mohsen Mhadhbi, Laboratory of Useful Materials, National Institute of Research and Physical-chemical Analysis, Technopole, Sidi Thabet, Tunisia.

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Abstract

The diagnostic process is a complex, collective actions that involves clinical analysis and gathering the information to determine a patient's health status. Using the saliva which is slightly alkaline secretion of water, mucin, protein, salts that is secreted into the mouth by specific glands called salivary glands can play an important role in clinical detection of systemic diseases Like diabetes and assist in diseases management and improvement. continuous researches, and the availability of technology, will have huge impact on diagnostic processes advancement and accuracy.

Keywords: *Nanotechnology; Nanomedicine; Vaccine; Nanoparticle*

Abbreviations

NPs: Nanoparticles; CNTs: Carbon Nanotubes; COVID-19: Coronavirus Disease 2019; SARS: Severe Acute Respiratory Syndrome; QD: Quantum Dots; DAMPs: Damage Associated Molecular Patterns; VLP: Virus-Like Particles; MERS: Middle East Respiratory Syndrome

Introduction

The COVID-19 has caused a heavy worldwide human loss. Over 101, 917, 147 patients have been infected, while over 2, 205, 515 have died, according to World Health Organization. These statistics have been dramatically rising up [1]. At the same time, the number of confirmed cases in Tunisia was 207, 468; while the number of deaths was 6, 680 [2] so far.

Most world counties have been opting for limited or total lockdown except nanotechnologist and nanotechnology laboratories and companies. They have been working hard since the beginning of the pandemic to provide solutions and support at many levels.

Nanotechnology has thus received increasing attention in several fields particularly in the medical one. The idea of employing nanotechnology in the battle against the SARS-CoV-2 virus has increasingly encouraged. Since the virus is a microscopic entity which naturally occurs similarly to nanomaterials, several approaches have been considered regarding the improvement of a vaccine and/or nano-formulations of therapeutics.

The KR20200032050 patent, for instance, focuses on the application of nanotechnology to face COVID-19 by using liposomes to transport the single standard DNA oligomer, which is used for targeting virus-infected cells [3]. Moreover, nanotechnologists from diverse areas have reflected on the advantageous potential of nano-formulations for the most promising therapeutic applicants, nanotechnological tools that may shorten worldwide vaccine manufacturing and distribution, nanomaterial-based viral disinfectants, and nanotechnology-based sensors detection platforms [4].

Ruiz-Hitzky., *et al*. [5] revealed that nanotechnology was a significant tool that provides several approaches, which can contribute to encourage researches in the world to face the lethal infections COVID-19 has caused.

Additionally, Itani., *et al.* [6] studied the role of nanoparticles as effective carriers for therapeutics or immune modulators to help in fighting face to COVID-19.

However, electrospinning was a powerful process employed for creating nanofiber membranes with desirable properties, involving the porosity ratio, fiber diameters, etc. [7-10]. It was revealed that SARS-COV-2 has a lower stability on the surface of metallic copper compared to other materials [11]. This review paper focuses on the role of nanotechnology face to the new pandemic (COVID-19).

Nanomedicine strategies for COVID-19

There are several nanomedicine strategies created for combating COVID-19 (Figure 1). They include vaccines (against SARS-CoV-2), coronavirus biology (life cycle, composition, and clinical phase), virus research (to understand COVID-19 mechanism), and therapeutics (to support and to target the immune system).

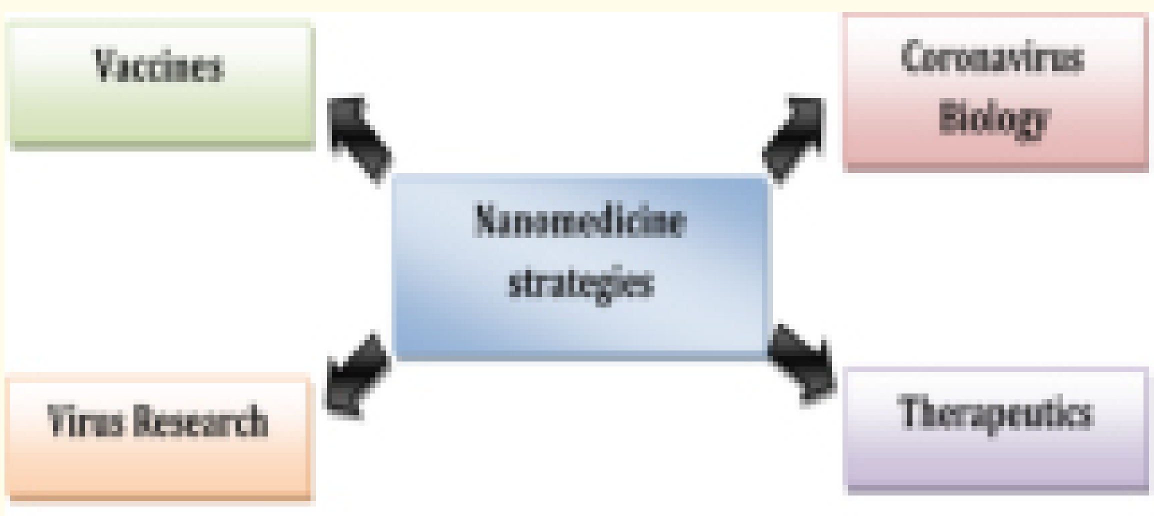

Figure 1: *Schematic representation of nanomedicine strategies.*

However, it has been shown that nanocarriers can be employed to function as either transport vehicles of a particular vaccine to reach immunization of the host [12]. They can be also used for different loading like gene therapy [13].

Figure 2 shows the nanotechnology platforms for vaccine development involving liposomes, dendrimers and polysaccharide particles, which are used for enhancing the stability of mRNA vaccine [14].

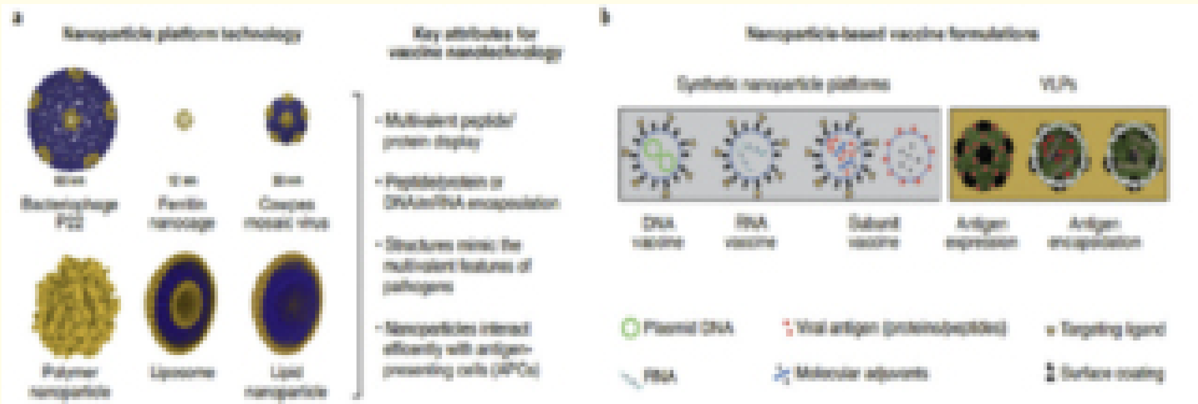

Figure 2: *Nanotechnology based technology for vaccine development [15].*

Figure 3 summarizes the distribution of patents dealing with SARS-COVID viruses within the coronaviruses and nano. As shown in the figure, the majority of patents are focused on membrane and detection (19%) and the minority are focused on disinfectant and virucide (1%) [16].

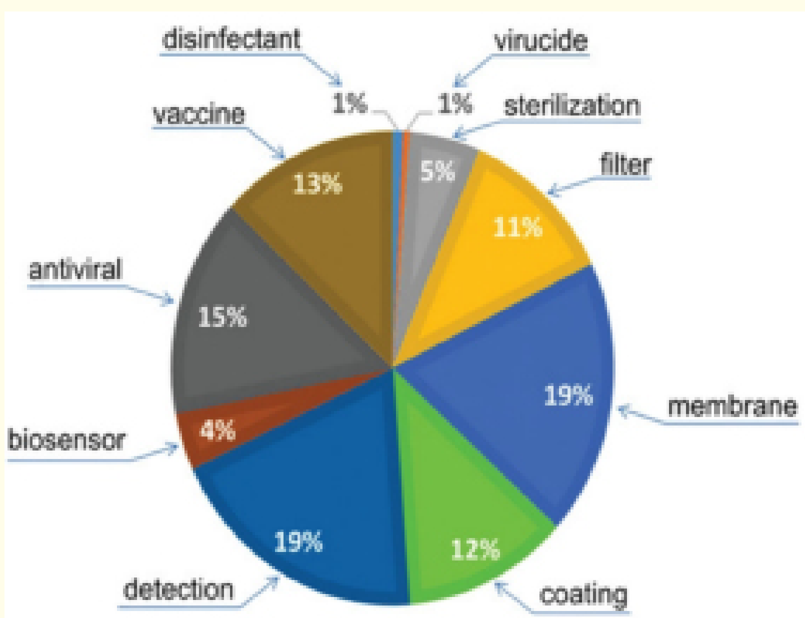

Figure 3: *Distribution of patents related to SARS-COV viruses within the coronaviruses and nano [16].*

Antiviral nanoparticles against COVID-19

A number of nanoparticles exhibit antiviral activity face to a range of viruses such as herpes, influenza, etc.

However, many types of theragnostic NPs were suggested as hopeful route for intranasal drug delivery [17]. Thus, they can be separated into three groups (organic, inorganic, and virus-like and self-assembling protein NPs), as given in figure 4.

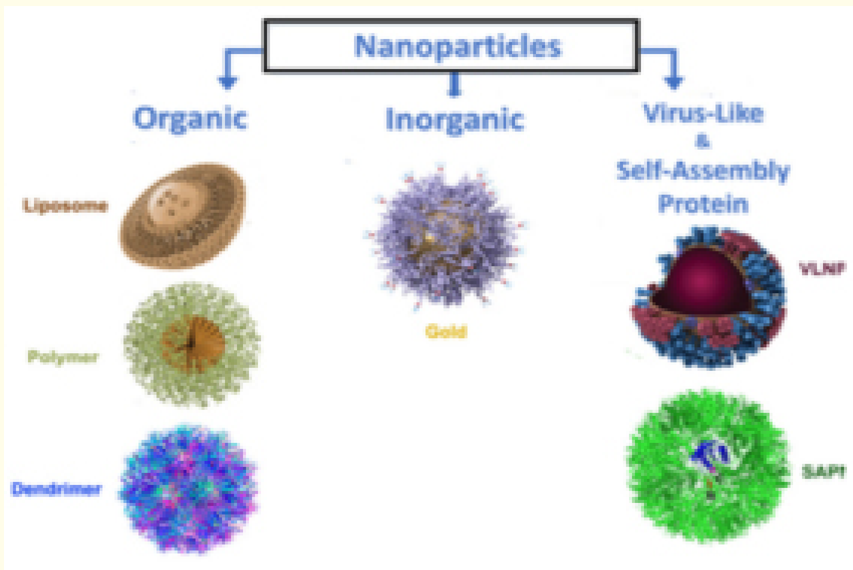

Figure 4: *Schematic representation of the various types of nanoparticles based delivery systems [15].*

The application of inorganic nanoparticles in COVID-19 therapy was related to their size, shape, broad range of chemical composition, facility of synthesize, and physical and biological properties [18,19]. In addition, it was shown that the copper and silver cations can provoke viral membrane disruption and can also damage the viral genome [19]. Moreover, some nanoparticles such as quantum dots, metal cations, metal oxides, and transition metal NPs have revealed intrinsic virucidal activity [18].

Nano-adjuvant

Nanoparticles based adjuvant are a kind of particles with a size less than 1000 nm, which can improve the immune response (efficacy and safety) of the human body. They are used as vaccines in clinical practice. Thus, it is a powerful tool which can help to improve current COVID-19 vaccine designs. Furthermore, the danger signals of the virus are characterized as a damage associated molecular patterns (DAMPs) extracted from the same virus [20]. Nano-adjuvant vaccine can act either an intrinsic physical and chemical properties to stimulate immunity pathway or as a nanocarriers for molecular adjuvant [21]. Additionally, Nano-adjuvant vaccine has a great role in reducing the needed antigen dose [22]. It has been shown that the co-encapsulation strategy permits the colocalisation of adjuvant and antigen in compartments (phagosomal and endosomal) [24].

Similarly, pluronic stabilized poly(propylene sulfide) nanoparticles can improve the cellular immunity [24].

Nanoparticles for diagnostic

Several type of nanoparticles were used for the virus detection, involving carbon nanotubes, quantum dots, polymeric, metal nanoparticles [25,26]. In fact, gold nanoparticles (AuNPs) are the better usual NPs in diagnostic because of their interested characteristics like good stability, optical, and biocompatible proprieties [27-29]. AuNPs generate a redshift in localized surface plasmon resonance peak position causing in an obvious modification in the solution color (from red to blue). Thus, this occurrence was generated by plasmonic coupling through the neighboring NPs [30]. Lee., *et al.* [31] developed a new technique to detect COVID-19 based on nanoplasmonic on chip PCR fabricated from gold NPs deposited on the side and top walls of glass nanopillar arrays used to improve the light absorption ability of the detection chip.

In the work reported by Qui., *et al.* [32], a dual functional plasmonic biosensor by integrating plasmonic photothermal effect and localized surface plasmon resonance sensing transduction shows an encouraging and good solution for COVID-19 detection (Figure 5). They concluded that the plasmonic photothermal heat is able to increase the hybridization temperature and to make easy the discrimination of two similar gene sequences. In addition, they revealed that the localized surface plasmon resonance biosensor shows a good sensitivity regarding the selected SARS-COVID-2 sequences and a lower detection limit (below 0.22 pM).

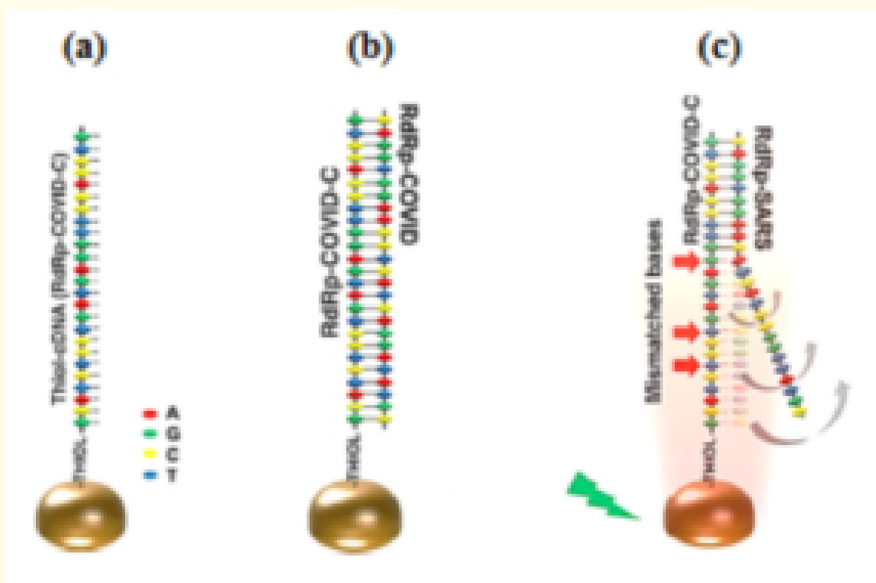

Figure 5: *Schematic presentations of: (a) cDNA receptor functionalized AuNI based on reaction with thiol- cDNA ligands, (b) hybridization of two complementary strands, and (c) hybridization of two matched sequences [32].*

In another research work [33], a nanostructured QDs with other NPs have been revealed for COVID-19 detection. Thus, CdTe QDs were incorporated with star sharped chiroplasmonic gold nanoparticles (AuNPs) to fabricate a biosensor with interesting properties.

Nanoparticles for vaccine

The aim of vaccination is to begin a powerful immune response that help human body to the development of protective immunity face to the pathogen attack.

The vaccines can be enabled by employing virus-like particles (VLP), which are a protein based nanoparticles involving viral envelope proteins without the association of genetic material [34]. Currently, Novavax has launched COVID-19 vaccines, based of VLP with Matrix-M adjuvant, to protect against coronavirus disease and to enhance immune responses [35-37]. Pimental., *et al.* [38] designed and produced a prototypic SARS vaccine by assembling polypeptide NPs with sizes of about 25 nm (As shown in figure 6). They concluded that these peptide NPs represent a good platform for vaccine design.

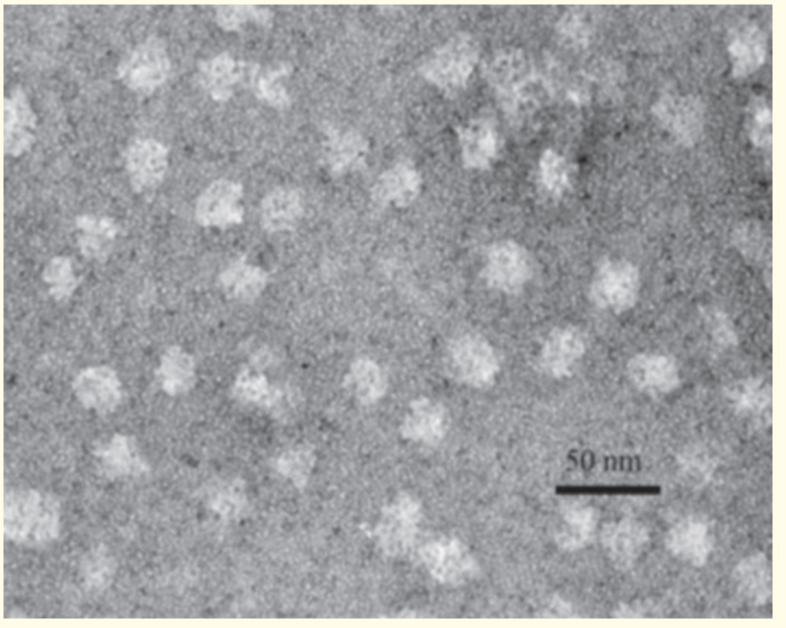

Figure 6: *TEM image of polypeptide nanoparticles [38].*

Nevertheless, Wang., *et al.* [39] designed a new vaccine based on chimeric VLP expressing the receptor-binding domain of Middle East respiratory syndrome coronavirus. They revealed that VLP displaying the receptor-binding domain are hopeful prophylactic candidates face to COVID-19 in a potential outbreak situation.

Carter., *et al.* [40] developed a novel self-assembling platform for bio-engineered NPs for a various applications involving vaccines. They concluded that the use of this system could accelerate the finding and development of vaccines for human health.

Kam., *et al.* [41] revealed that trimeric SARS-COVID-19 *S* protein vaccine induce a protective immune response in mice the anti-*S* antibodies moderated antibody dependent improvement of viral entry into human *B* cells. Additionally, the use of SARS *S* protein vaccine may cause enhanced disease and immunopathology instead of protection as noticed for feline coronavirus [42].

Conclusion

The application of nanotechnology in the field of medicine is a powerful method which offers different approaches that could contribute to promise various researches to prevent coronavirus disease. Nanotechnology has demonstrated its efficacy at the prevention, diagnosis, and treatment of the COVID-19 disease. Several works are also required for further detailed understanding of the nanotechnology to face the new COVID-19 or other upcoming diseases.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Bibliography

1. "World Health Organization" (2020).

2. "World Health Organization" (2020).

3. Kim SC. "Patent number KR20200032050A" (2020).

4. "Editorial on Nanotechnology Versus Coronavirus". *Nature Nanotechnology* 15 (2020): 617.

5. Eduardo RH., *et al*. "Nanotechnology Responses to COVID-19". *Advanced Healthcare Materials* 9 (2020): 2000979.

6. Rasha I., *et al*. "Optimizing use of theranostic nanoparticles as a life-saving strategy for treating COVID-19 patients". *Theranostics* 10.13 (2020): 5932-5942.

7. Al-Wafi R., *et al*. "Mechanical, microstructural properties and cell adhesion of Sr/Se-hydroxyapatite/graphene/polycaprolactone nanofibers". *Journal of Thermoplastic Composite Materials* (2020): 089270572091278.

8. Ahmed MK., *et al*. "Au-doped carbonated hydroxyapatite sputtered on alumina scaffolds via pulsed laser deposition for biomedical applications". *Journal of Materials Research and Technology* 9 (2020): 8854-8866.

9. Ahmed MK., *et al*. "Complex relationship between alumina and selenium-doped carbonated hydroxyapatite as the ceramic additives to electrospun polycaprolactone scaffolds for tissue engineering applications". *Journal of Alloys and Compounds* 801 (2019): 70-81.

10. Ahmed MK., *et al*. "Tuning the mechanical, microstructural, and cell adhesion properties of electrospun ε-polycaprolactone microfibers by doping selenium-containing carbonated hydroxyapatite as a reinforcing agent with magnesium ions". *Journal of Materials Science* 54 (2019): 14524-14544.

11. Doremalen N., *et al*. "Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1". *The New England Journal of Medicine* 382.16 (2020): 1564-1567.

12. Pati R., *et al*. "Review on Nanoparticle vaccines against infectious diseases". *Frontiers in Immunology* 9 (2018): 1-16.

13. Coutelle C and Williamson R. "Liposomes and viruses for gene therapy of cystic fibrosis". *Journal of Aerosol Medicine* 9.1 (1996): 79-88.

14. Zeng C., *et al*. "Leveraging mRNAs sequences to express SARS-CoV-2 antigens in vivo". *BioRxiv* (2020): 1-16.

15. Matthew DS., *et al*. "COVID-19 vaccine development and a potential nanomaterial path forward". *Nature Nanotechnology* 15 (2020): 646-655.

16. European Patent Office, "ESPACENET Patent Search". (2020).

17. Itani R., *et al*. "Review on Optimizing use of theranostic nanoparticles as a life-saving strategy for treating COVID-19 patients". *Theranostics* 10.13 (2020): 5932-5942.

18. Chen L and Liang J. "An overview of functional nanoparticles as novel emerging antiviral therapeutic agents". *Materials Science and Engineering C* 112 (2020): 110924.

19. Singh L., *et al*. "The role of nanotechnology in the treatment of viral infections". *Therapeutic Advances in Infectious Disease* 4.4 (2017) 105-131.

20. Gallucci S and Matzinger P. "Danger Signals: SOS to the Immune System". *Current Opinion in Immunology* 13 (2001): 114-119.

21. Irvine DJ., *et al*. "Synthetic Nanoparticles for Vaccines and Immunotherapy". *Chemical Reviews* 115 (2015): 11109-11146.

22. Reed SG., *et al*. "New Horizons in Adjuvants for Vaccine Development". *Trends in Immunology* 30 (2009): 23-32.

23. Blander JM and Medzhitov R. "Regulation of Phagosome Maturation by Signals from Toll-Like Receptors". *Science* 304 (2004): 1014-1018.

24. Reddy ST., *et al*. "Exploiting Lymphatic Transport and Complement Activation in Nanoparticle Vaccines". *Nature Biotechnology* 25 (2007): 1159-1164.

25. Park JE., *et al*. "Metal Nanoparticles for Virus Detection". *Chem Nano Mat* 2 (2016): 927-936.

26. Mokhtarzadeh A., *et al*. "Nanomaterial-Based Biosensors for Detection of Pathogenic Virus". *Trends in Analytical Chemistry* 97 (2017): 445-457.

27. Draz MS and Shafiee H. "Applications of Gold Nanoparticles in Virus Detection". *Theranostics* 8 (2018): 1985-2017.

28. Dykman LA and Khlebtsov NG. "Gold Nanoparticles in Biology and Medicine: Recent Advances and Prospects". *Acta Naturae* 3 (2011): 34-55.

29. Khan MS., *et al*. "Gold Nanoparticles: A Paradigm Shift in Biomedical Applications". *Advances in Colloid and Interface Science* 199-200 (2013): 44-58.

30. Ghosh SK and Pal T. "Interparticle Coupling Effect on the Surface Plasmon Resonance of Gold Nanoparticles: From Theory to Applications". *Chemical Reviews* 107 (2007): 4797-4862.

31. Lee Y., *et al*. "Nanoplasmonic on-Chip PCR for Rapid Precision Molecular Diagnostics". *ACS Applied Materials and Interface* 12 (2020): 12533-12540.

32. Qiu G., *et al*. "Dual-Functional Plasmonic Photothermal Biosensors for Highly Accurate Severe Acute Respiratory Syndrome Coronavirus 2 Detection". *ACS Nano* 14 (2020): 5268-5277.

33. Ahmed SR., *et al*. "Self-Assembled Star-Shaped Chiroplasmonic Gold Nanoparticles for an Ultrasensitive Chiro-Immunosensor for Viruses". *RSC Advances* 7 (2017): 40849-40857.

34. Medhi R., *et al*. "Nanoparticle-Based Strategies to Combat COVID-19". *ACS Applied Nano Materials* 3 (2020): 8557-8580.

35. Lung P., *et al*. "Nanoparticle Formulated Vaccines: Opportunities and Challenges". *Nanoscale* 12 (2020): 5746-5763.

36. Coleman CM., *et al*. "MERS-CoV Spike Nanoparticles Protect Mice from MERS-CoV Infection". *Vaccine* 35 (2017): 1586-1589.

37. World Health Organization (WHO). "Draft Landscape of COVID-19 Candidate Vaccines" (2020).

38. Pimentel TAPF., *et al*. "Peptide Nanoparticles as Novel Immunogens: Design and Analysis of a Prototypic Severe Acute Respiratory Syndrome Vaccine". *Chemical Biology and Drug Design* 73 (2009): 53-61.

39. Wang C., *et al*. "Novel Chimeric Virus-Like Particles Vaccine Displaying MERS-CoV Receptor-Binding Domain Induce Specific Humoral and Cellular Immune Response in Mice". *Antiviral Research* 140 (2017): 55-61.

40. Carter DC., *et al*. "A Unique Protein Self-Assembling Nanoparticle with Significant Advantages in Vaccine Development and Production". *Journal of Nanomaterials* 2020 (2020): 4297937.

41. Kam YW., *et al*. "Antibodies against trimeric S glycoprotein protect hamsters against SARS-CoV challenge despite their capacity to mediate FccRII-dependent entry into B cells in vitro". *Vaccine* 25 (2007): 729-740.

42. Corapi W.V., *et al*. "Monoclonal antibody analysis of neutralization and antibody-dependent enhancement of feline infectious peritonitis virus". *Journal of Virology* 66 (1992): 6695-6705.

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